Composted versus fresh distillers grain and solubles derived manure as nutrient source for canola

J.J. Stefankiw, J.J. Schoenau, and R.E. Farrell

Introduction

Distillers' Grains and solubles are a by-product of ethanol production and consist of coarse grain particles as well as a slurry. In the ethanol production process the grain, usually corn or wheat, is fermented and distilled to produce ethanol. The ethanol is removed and the wet stillage is separated into liquids (thin stillage) and solids (wet distillers' grains)(Figure 1). The thin stillage is then evaporated to produce condensed distillers' solubles and the wet distillers' grains are also dried and can be mixed in with the condensed distillers' solubles to create dried distillers' grains and solubles (DDGS) (Department of Agriculture and Food, Western Australia, 2007).

DDGS has become increasingly popular as an additive in beef cattle feed rations due to the high protein content. The increased protein in the cattle diets can alter the manure nutrient composition. In a study by Hao et al. (2009) DDGS-fed cattle manure had increased concentration of N and P compared to barley-fed cattle manure. The change in nutrients in the manure is important to its properties as an organic fertilizer for crops.

Meeting crop nutrient demands is important when adding any fertilizer. Manure as a soil amendment is a slow-release form of N fertilizer due to most of the N being in the organic form and requires mineralization and nitrification before it can be available for plant uptake (Qian and Schoenau, 2002). Thus, it important to take into account the N recovery from manure to understand how the manure can meet the crop requirements for N in the first year of application. N recovery from different types of manure can be different depending on the handling, processing, and feed source of the manure. Knowledge of crop N recovery is important when determining appropriate application rates (Mooleki et al., 2004).

This study's objective was to determine the effect of fresh and composted DDGS wheat and DDGS corn manures on the nutrient uptake and dry matter yield of canola under controlled environment conditions.

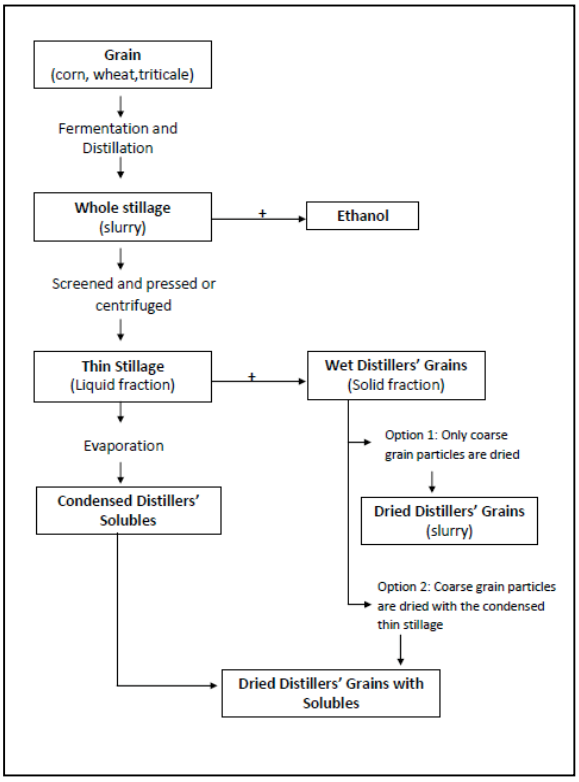

Figure 1 - Flow chart of how distillers' grains and solubles are created from ethanol production (Adapted from Department of Agriculture and Food, Western Australia, 2007).

Materials and Methods

The study was based on a completely randomized design with four types of manures: DDGS wheat fresh, DDGS wheat compost, DDGS corn fresh, DDGS corn compost. The manure amendments were added to the soil at four rates: 60, 120, 180, and 240 t/ha and control (0 t/ha) with four replicates

of each treatment. The soil used in the pots was a loam textured soil collected from the top 0 to 15 cm of the soil profile of a wheat stubble field in the Brown soil zone (Haverhill association).

The manure was incorporated into 1 kg of soil before placing in a 20 cm pot. Each pot was seeded with ten canola (Brassica napus) Invigor 5030 seeds which were then thinned out to five seedlings per pot once germinated. The pots were placed in a growth chamber with 16 hour days at 24°C and 8 hour nights at 21°C and were watered to 80 % field capacity daily. Plants were grown in the growth chamber for 35 days (five weeks) at which time they were harvested and soils and plants were analyzed.

Results and Discussion

The DDGS composted manures showed increased N and P content compared to the fresh cattle manures (Figure 2). Overall the DDGS wheat composted manure had the highest N and P contents making this manure a more concentrated nutrient source. The composting process concentrates nutrients because of the evaporation of water decreases the volume of material (Larney et al., 2006).

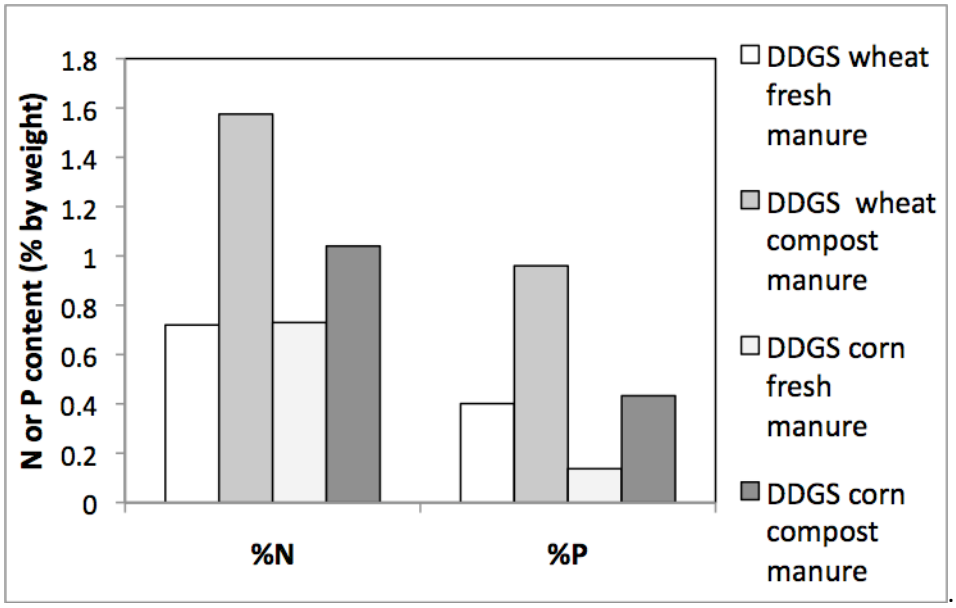

Figure 2 – N and P content of the composted and fresh DDGS wheat and DDGS corn-fed cattle manure.

The rate of N addition to the soil is different for each type of manure because there are differing N contents and the manure was added on a weight basis (Table 1). The DDGS wheat composted manure shows high N rates which may exceed the crop N demands making the N available for loss through erosion.

Table 1 – Rate of manure addition and N rate for each manure type.

Manure Rate		Wheat Fresh	Wheat Compost	Corn Fresh	Corn Compost
(g/kg)	(t/ha)	----------N Rate (mg/kg)----------			
30	60	216	**474**	219	312
60	120	432	**948**	438	624
90	180	648	**1422**	657	936
120	240	864	**1896**	876	1248

DDGS wheat manure tended to produce the highest canola biomass yield. At lower rates of manure addition, composted manure tended to result in higher yield than fresh manure (Figure 3). The concentrated nutrients in the composted manure may have produced a toxic effect when added at the higher rates.

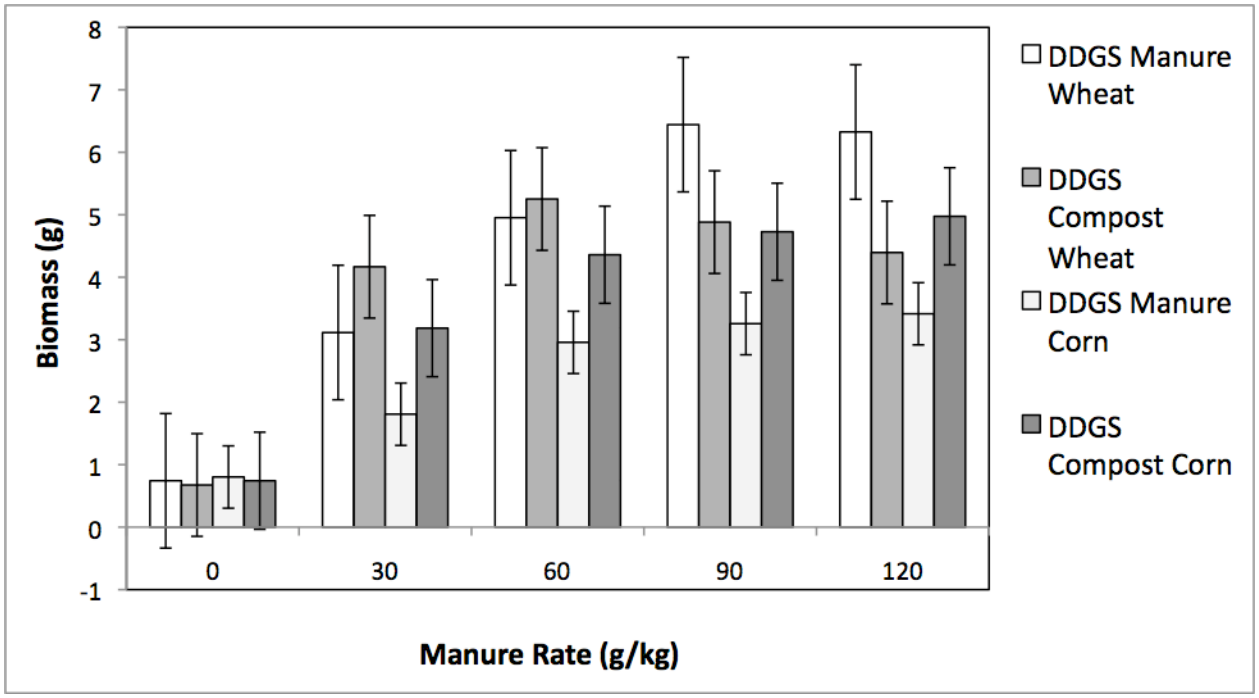

Figure 3 – Mean dry plant biomass (g) for each manure type at the five different rates. Bars represent standard error.

The N recovered by the canola plants was calculated with the following formula from Mooleki et al. (2004):

$$\text{NUE}\,(\%) = \frac{\text{Crop N Uptake}_{(\text{manure treated})} - \text{Crop N uptake}_{(\text{Control})}}{\text{N applied as manure}} \times 100$$

Crop N recovery increased with increasing manure rate with the DDGS wheat fresh manure and the DDGS composted corn manure (Figure 4). There is a decrease in N recovery in the DDGS composted wheat manure at the highest rate of manure addition. The decrease may be due to a toxic effect of the high concentration of nutrients from this manure source. The DDGS composted corn treatment also decreases in N recovery with increasing rate and showed lower N recovery values compared to all other treatments. This manure also had low N content and higher C:N value which would explain the low N availability to the plants.

Overall low N recovery values (<10%) agree with results of Mooleki et al. (2004) in field trials with recovery of fresh cattle manure N in year of application in Saskatchewan. Much of N in cattle manure is in organic form and is mineralized slowly over time to plant-available forms of N such as NO_3 and NH_4 (Eghball, 2002).

Nitrate and NH_4 were in relatively low concentrations in the soil which is expected when manure is added because it is mainly organic N. Soil available NO_3 in the 240 t/ha DDGS composted manure treatment (mean NO_3=10.66 ug/g) was significantly higher than all other treatments. This was due to the decreased plant uptake of N by the plant at the highest rate which can be because of plant toxicity.

Mean NH_4 ranged from 3.98 ug/g in the control treatment to 8.85 ug/g in the DDGS wheat composted treatment at the 60 g/kg rate.

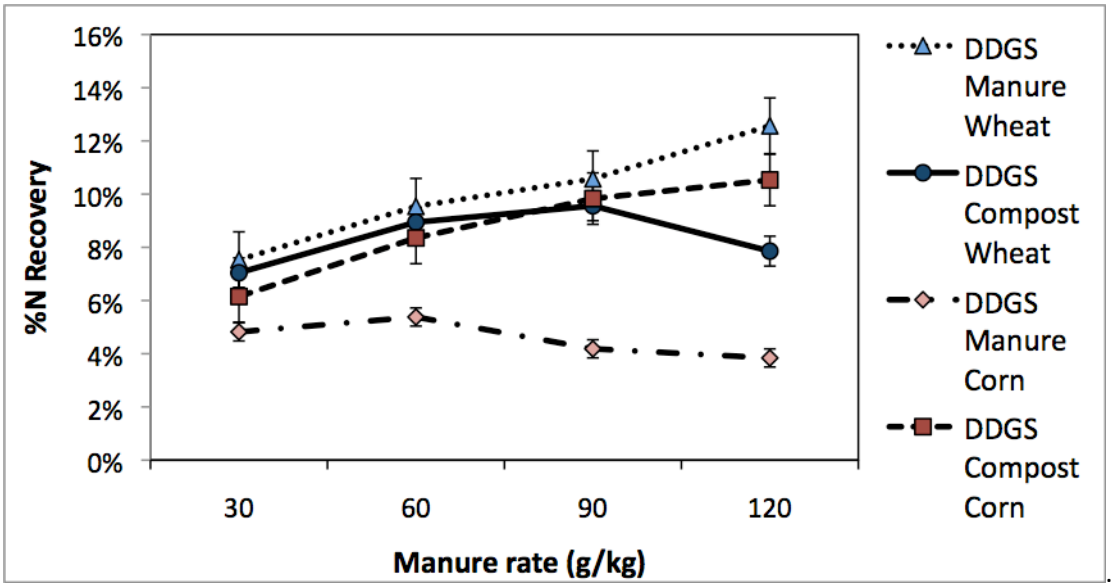

Figure 4 – Nitrogen recovery by each of the four types of DDGS manure at four different rates.

The DDGS wheat composted manure treatment shows similar trends for mean PO_4, SO_4, EC, and OC with increasing levels with increasing rate of manure addition (Figures 4, 5, 6, and 7). The PO4 levels in the soil are relatively high in the DDGS wheat composted manure treatment at the 90 g/kg and 120 g/kg rates. The high levels in the soil following the growing season indicates that there is more PO4 in the soil than can be taken up by the plant, therefore there is PO_4 available to be lost in run-off or leach lower in the soil profile.

The organic carbon levels also increase with increasing rate for DDGS composted treatment with the 120 g/kg rate being significantly higher than all other treatments (Figure 6). There are no other trends of increasing OC with increasing rate with the other manure types.

Soil electrical conductivity (EC) increases with increasing rate in the DDGS wheat composted treatment with the 90 g/kg and 120 g/kg rates having significantly increased EC compared to all other treatments (Figure 7). These treatments may show signs of plant toxicity due to the high salts in the manure treatments. Sulphate levels follow the same trend as EC with the DDGS wheat composted treatment increasing with increasing rate (Figure 8).

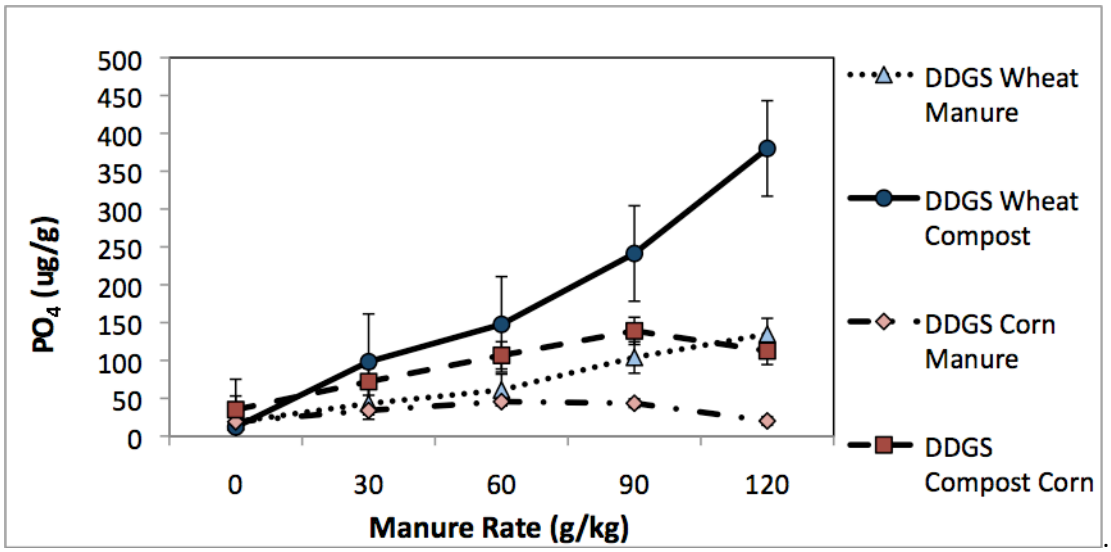

Figure 5 - Mean PO4 (ug/g) for each manure type at the five manure rates. Bars represent standard error.

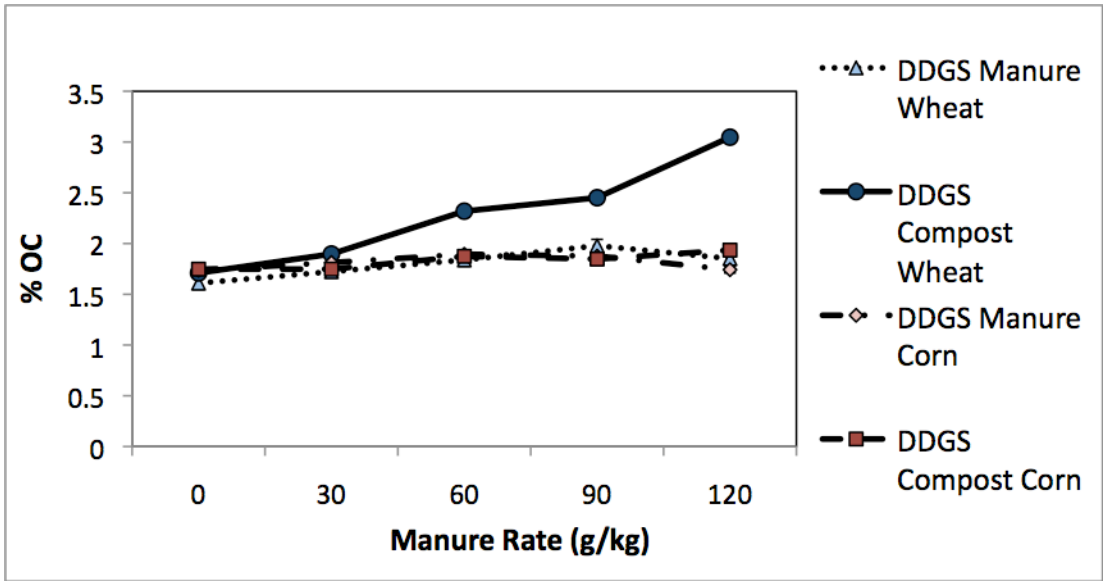

Figure 6 – Mean % organic carbon (OC) for each of the four manure types at the five different rates.

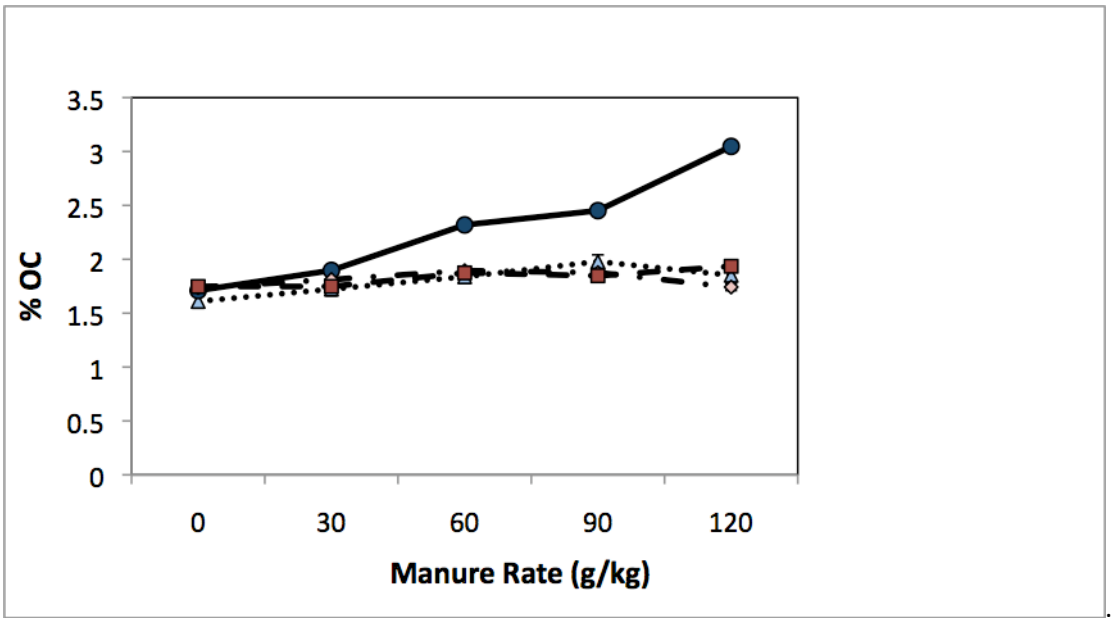

Figure 7 – Mean electrical conductivity (uS/cm) of the four different manure types at five rates of application.

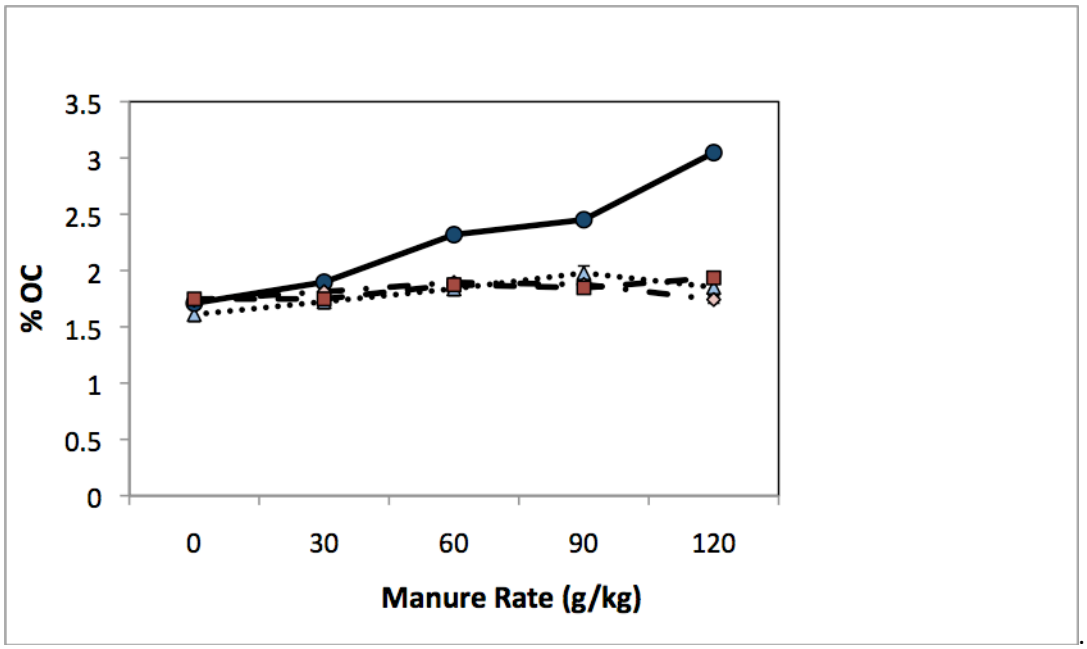

Figure 8 – Mean SO4 (ug/g) for each of the four manure types at five rates of application.

Conclusion

DDGS wheat based, composted manures produced the highest canola biomass yields. Composted treatments resulted in higher soil residual P levels compared to the fresh manure treatments, in line with higher manure P content. Nitrogen in DDGS wheat manures in general was recovered by canola to a greater extent compared to the DDGS corn manures. DDGS wheat compost manure showed a trend of increased EC, OC, P, and S with increasing rates. Optimum rate of DDGS manure will be influenced by feed grain source and manure processing.

References

Department of Agriculture and Food, Western Australia. 2007. [Online] Available at: http://www.agric.wa.gov.au/objtwr/imported_assets/content/sust/biofuel/potentialusesgrains042007.pdf

Eghball, B., B.J. Wienhold, J.E. Gilley, and R.A. Eigenberg. 2002. Mineralization of manure nutrients. Journal of Soil and Water Conservation. 57(6): 470-473.

Eghball, B., D. Ginting, and J. E. Gilley. 2004. Residual effects of manure and compost applications on corn production and soil properties. Agron. J. 96:442-447.

Hao, X., M. B. Benke, D. J. Gibb, A. Strongs, G. Travis, and T. A. McAllister. 2009. Effects of dried distillers' grains with solubles (wheat–based) in feedlot cattle diets on feces and manure composition. J. Environ. Qual. 38:1709-1718.

Larney, F.J., D.M. Sullivan, K.E. Buckley, and B. Eghball. 2006. The role of composting in recycling manure nutrients. Can. J. Soil Sci. 86: 597-611.

Mooleki, S. P., J. J. Schoenau, J. L. Charles, and G. Wen. 2004. Effect of rate, frequency and incorporation of feedlot cattle manure on soil nitrogen availability, crop performance, and nitrogen use efficiency in east-central Saskatchewan. Can. J. Soil Sci. 84:199-210.

Qian, P. and J.J. Schoenau. 2002. Availability of nitrogen in solid manure amendments with different C:N ratios. Can. J. Soil Sci. 82: 219-225.